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ABSTRACT

One area explored in the second (in-depth) phase of the Learning in Science Project was "children's science," defined as views of the world and the meanings for words that children have and bring with them to science lessons. The investigation reported focuses on the concept of "plant" held by 29 students. Data were obtained by the "interview-about-instances" procedure in which students were shown cards with diagrams which represented different instances (grass) and non-instances (elephant) of the concept. Students were asked "In your meaning of the word 'plant,' is ...(the drawing shown)... a plant?" At the end of the interview, students were then asked to give their meanings of the word in a sentence or two. Responses are presented, discussed, and analyzed according to: (1) the use of scientifically acceptable critical attributes (leaves, flowers, and others); (2) the use of scientifically unacceptable critical attributes (size, hardness, and others); (3) the use of critical attributes of living things as the critical attributes of plants; and (4) the atypical plants (seaweeds, seeds, and others). Among results are findings that only four students could categorize instances.non instances correctly. Sample interview cards and additional quotations, under the same four headings enumerated above, are provided in an appendix. (JN)

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LEARNING IN SCIENCE PROJECT

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PLANTS

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WORKING PAPER No. 24

In our view successful science teaching requires an appreciation not only of the scientists' view of the world, but also an appreciation of the language, the beliefs and the expectations which children bring with them to science classes. This working paper has developed from a study carried out in the in-depth phase of the Learning in Science Project and is one of a series of papers which explores aspects of Children's Science (see Working Paper No. 14). It is our hope that these papers portray children's views of the world and meanings for words in a way which will be useful to teachers and to curriculum developers.

In the action-research phase of the project it is our intention to attempt to build practical and useful teaching strategies based on the findings of the in-depth phase of the project. For this reason we are actively seeking comments on the findings we have detailed, and seeking information on the variety of ways teachers develop ideas associated with the topic under focus in this paper.

We would be grateful if comment and/or information could be forwarded to

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HAMILTON.

PLANTS

A working paper of the Learning in Science Project

Beverley Stead

December, 1980

INTRODUCTION

This investigation describes the concepts of 'plant' held by some 29 pupils in four different class levels - Standard 4, Form 1, Form 3 and Form 5.

The method of obtaining data was an 'interview-about-instances' procedure developed by Osborne and Gilbert (1979). This method is based on the idea that a particular concept held by a person can be explored by asking the person to distinguish between instances and non-instances of the scientifically accepted concept and by asking them to give the reasoning behind their action.

With respect to the concept 'plant' for example, a person is said to have the scientifically acceptable concept if (s)he can distinguish between instances of the concept (eg grass, pine tree, poppy) and non-instances (eg horse, car, fire) and give scientifically acceptable reasons for the action. To a biologist plants differ from animals (in the five kingdom classification system) in that they carry out autotrophic feeding (green plants carry out photosynthesis); they possess cells with cell walls, and plants do not move nor possess well developed nervous systems as do many animals. Such reasons, in fact, represent one or more of the set of criterial attributes for the concept. The acceptable scientific reasons are the criterial attributes for the concept. The acceptable scientific reasons are the criterial attributes that would be used by a biologist to distinguish between instances and non-instances. Not all attributes or characteristics are criterial, of course. Whilst plants need water and carry out gaseous exchange, so do animals. These two characteristics are not criterial attributes of plants, they do not distinguish plants from other living things.

Pupils often do not distinguish between instances and non-instances in a scientifically acceptable manner, nor is their reasoning always based on scientifically acceptable criterial attributes. However, exploring pupils' concepts in the manner described above can lead to an understanding of not only whether pupils hold a scientifically acceptable concept, but, perhaps even more importantly, what concept they do hold. Initial interviews with children can lead to the inclusion of certain 'instances' and 'non-instances' of a concept in the interview schedule which enable the non-scientific concepts held by children to be identified more clearly.

Twenty-nine pupils from 3 different schools, across 7 classes were interviewed. The teachers were asked to select children of average ability for the investigation. However, this was not always possible and the pupils of above average ability are indicated in Figure 1.

In an interview situation, the pupils were shown diagrams on cards (only one per card) which represented different instances and non-instances of the concept of 'plant'. The illustrations on the cards shown, in order of presentation were: grass, elephant, seaweed, poppy, thistle, seeds, tree, and cabbage. A sample of the cards is illustrated in Figure 2.

The interviews were structured in the sense that the sequence of cards was the same, and the same two questions were asked with each card in the interview. The two questions asked were:

1. 'Is the _____ a plant?'
2. 'What tells you that?'

The first question investigated if the pupils categorised the instance as an exemplar or non-examplar of the concept; the second investigated the reasoning (the set of criterial attributes) used to make the categorisation. However, further questions were asked when appropriate, in order to gain a clearer understanding of each pupil's concept under investigation. The beginning of each interview, after introductions, was as follows:

> "I'm interested in science lessons and, in particular, the different meanings people have for different words. For example, the teacher may use a word in a class, you'll mean one thing by it and the person sitting next to you may mean something slightly different. I would like to learn from you what you mean by the word 'plant'."

The first question with the first card (and with later cards if need be) was "In your meaning of the word 'plant', is a _____ a plant?" At the end of the interview the pupil was asked to give her/his meaning of the word 'plant', in a sentence or two.

The pupils were individually interviewed in a small room or office. The interviews were taped with the consent of the pupil, and later transcribed to obtain a written record of the interview for the later collation of results.

ANALYSIS OF THE INTERVIEW TRANSCRIPTS

The criterial attributes as perceived by the pupils were used to determine the framework of the analysis. (Table 1).

Statements made in the analysis are illustrated or supported with quotations from the transcripts. An example of such a quotation is:

"Yes, ... it's green". (Fern, 022, 320, 321, 324, 517)

The interpretation of this quote is as follows:

1. The "Yes" was the answer given to the first question, "Is the fern a plant?" The fern was categorised as a plant.
2. "it's green" was the reply to the second question "What tells you that?" That "it is green" was the attribute used to categorise the fern as a plant.
3. "Fern" indicates the instance to which this quote refers.
4. The number 022 indicates the pupil whose answer is quoted.
5. Numbers 320 to 517 indicates the pupils who gave answers, similar in meaning to that of pupil 002, but not necessarily identical in wording.

6. The triple code number, eg. 320, represents one pupil. The first number indicates the class level. (0 for Standard 4; 1 for Form 1; 3 for Form 3; and 5 for Form 5.) The next two numbers refer to a particular pupil. For example, pupil 320 was the twentieth pupil interviewed from Form 3.

Only two or three representative quotations have been given in the analysis section to illustrate any one point. Interested readers are referred to the Appendix for a more comprehensive record of the interview transcripts.

The Use of Scientifically Acceptable Criterial Attributes

As mentioned above plants and animals (in the five kingdom classification system) may be primarily distinguished on feeding, and cell structure. However, most plants do not move nor possess well developed nervous systems as do many animals. The attributes of autotrophic feeding and cells with a cell wall, may be unknown to many intermediate and junior secondary school pupils. The pupils used other criterial attributes, which although not characteristic of all plants, do pertain more to plants than to animals. Only four of the 29 pupils correctly categorised the plants as such, using the following characteristics as criterial attributes.

The most often used attribute to categorise a plant was:

a. It grow in the ground

"Yes, it grows in the ground." (Grass, 023, 026, 117, 119, 122, 318, 321, 322, 323, 518, 522)

Other attributes used were:

b. Leaves

"Yes, ... it's got leaves." (Dandelion, 021, 022, 023, 024, 026, 118, 119, 122, 318, 324, 522)

c. Flowers

"Yes, ... it's got flowers." (Poppy, 022, 021, 023, 024, 025, 026, 118, 120, 121, 319, 321, 322, 323, 324, 517, 519, 520)

d. Stem

"Yes, .. the stem." (Thistle, 119, 318, 324, 520)

e. Colour

"Yes, ... it's green." (Fern, 022, 320, 321, 324, 517)

f. Roots

"Yes, ... it has roots like other plants ..."
(Tree, 120, 318, 324, 523)

g. Requirements

"They (plants) need sunlight, they need water."
(Bracken, 023, 318)

h. Immobility

"Yes, ... and it doesn't run around."
(Seaweed, 123, 320, 519)

The Use of Scientifically Unacceptable Criterial Attributes

Some pupils used criterial attributes that would not be used by a biologist.

a. Size Some pupils considered plants to be small in size.

"No, it was a plant, when it was little but when it grows up, it wasn't, when it became a tree it wasn't."
(Tree, 020, 320, 520)

b. Hardness Some pupils considered plants to be soft.

"Well, the trunk isn't a plant but the leaf parts are like a plant. They do the same thing as a plant. (Why would you say the trunk part wasn't a plant?) Because it's hard."
(Pinetree, 521)

c. Plants are those which are Cultivated

"Yes, ... it doesn't grow wild, you need to grow it."
(Poppy, 320)

The word 'weed' was used:

"Yes, I'd also call it a weed."
(Thistle, 321; grass, 518
dandelion, 521)

Some pupils saw weeds, not as plants but as a separate group of organisms.

"No, it's a weed, it grows naturally."
(Grass, 320)

"No, ... it's a weed ... its leaves ... they're really ugly."
(Dandelion, 518)

One pupil acknowledged a double meaning for the word 'plant':

"Oh, ... plant is a general term for all forms that grow, like a flower plant or a cabbage plant; or particular kinds of plants, ones that you would actually put in the ground."
(Grass, 522)

d. Soil as a food source

Some pupils saw a characteristic of plants as getting their food from the soil:

"Yes, ... get their food from the ground"
(Dandelion, 320; fern, tree, 521)

"Yes, it gets all its nourishment out of the ground."
(Poppy, 321)

"Yes, ... lives off the soil." (Tree, 323)

Only secondary school students mentioned this as an attribute. Perhaps this scientifically incorrect concept had been learnt during the teaching on nutrients (the minerals) in the soil, and their uptake by the roots. This type of response was also given in the 'energy' interviews. (Working paper No. 17)

e. Idiosyncratic uses of a characteristic

"Yes, from this book I read, it's got the plant that saved Scotland .." (Thistle, 023)

The Use of the Criterial Attributes of Living Things as the Criterial Attributes of Plants

The attributes of living things were used, and whilst they are characteristics of plants, they do not distinguish plants from other living things, namely the animals.

"Yes, it grow." (Seaweed, 026, 120, 122, 123, 319, 322, 323, 519, 522, 523)

"Yes, ... (it's) able to reproduce itself." (Grass, poppy, 521)

"Yes, it's living." (Gorse, 521)

The Atypical Plants

a. Seaweed

Most pupils categorised this as a plant, using the attributes already mentioned. Most recognised it as a water plant. However, two pupils did not categorise it as a plant:

"No, it's in the water." (019)

"No, it's growing under the water, and it wouldn't be green - it would be a brownish colour." (520)

b. Mushrooms This was classified by half the pupils as a plant.

"Yes, ... its a fung(us)." (321)

"Yes, ... it grows in the ground." (026, 117, 122, 321, 521)

The other half did not consider it a plant:

> "No, it's got no leaves or flowers or nothing that plants have." (118)
>
> "Not sure whether it's got roots or not ... it grows in the ground like a plant though, not sure." (318)
>
> "No ... I don't think so because mushrooms grow in decaying matter" (521)
>
> "No, ... its got no chlorophyll." (520)

Biologists, themselves, are in disagreement as to whether to include the fungi in the plant kingdom or not.

c. <u>The Vegetables - carrot and cabbage</u>

Thirteen of the 29 pupils interviewed did not categorise the carrot nor the cabbage as a plant but as a vegetable:

> "No, it's a vegetable, when we chop something up for a stew, we eat it." (Carrot, 019, 026, 323, 518, 521, 523)
> (Cabbage, 118)

These pupils had restricted the concept of 'plant'.

Other pupils distinguished between the root and the foliage systems:

> "Yes and no - it's a plant - there are leaves that stick out of the ground when the carrot's growing ... and you can pull it out and eat it - (it's) a vegetable." (Carrot, 022, 025)
>
> "Not the carrot itself ... (it's) a vegetable ... the thing we can eat. (What about the other part?) It would be a plant." (Carrot, 122, 318)

Some pupils classified them as both as plants and vegetables:

"Yes, a carrot's a vegetable, which is a plant, grows into the ground and it's still got greeny on top"
(Carrot, 321)

"It's a plant and a vegetable - it's got leaves, grows in the ground and you can eat a cabbage carrot)."
(Cabbage, 002, 121, 123, 323, 324)
(Carrot, 119, 121, 123, 324)

Others acknowledged that the vegetables were plants as well as vegetables but did not use the words themselves:

"Yes, it grows and you can eat it."
(Carrot, 023, 120, 320, mushroom; 023, 120)
(Cabbage, 120, 517)

Others acknowledged it as a plant only:

"Yes, it's got the leaves and it's got roots.
(Carrot, 319, 517, 522)

d. <u>The seeds</u>

Eighteen of the 29 pupils interviewed did not consider the seeds to be plants:

"No, not until they grow ..."(117, 118, 121, 322, 323, 520, 522)

But some students did categorise them as plants:

"Yes, because that grows into a plant."
(020, 019, 021, 123, 518, 521)

"Yes, they're seeds off plants and they will grow into plants."
(119, 321, 324, 517, 519)

SUMMARY

Only four pupils (119, 123, 321, 519) could categorise the instances and non-instances as would a biologist and use scientifically acceptable concrete attributes, e.g. leaves, roots, immobility, grows in the ground. A further six pupils categorised the instances correctly, except for either the seeds or the mushroom. No pupil used the more abstract criterial attributes of cell structure or autrotrophic feeding, as would a biologist.

Many of the pupils interviewed, then, had a restricted concept of 'plant' compared to that of a biologist. These pupils' concepts had a narrow range of exemplars and excluded such scientifically acceptable exemplars, as the vegetables, weeds and seeds.

This restriction usually resulted from an inability to distinguish the relevant criterial attributes from a range of characteristics. The pupils' sets of characteristics for categorising instances and non-instances were often inconsistent and often differed from the biological ones.

Most pupils did not classify the instances and instances in hierarchical relationships as would a biologist. Whilst they grouped like instances together, they did not indicate an understanding of superordinate classes (e.g. plant) and subordinate classes (e.g. flowering plant). Many biological subsets were seen as comparable sets to the set 'plant'. This may be represented as:

living things

plants vegetables weeds trees other living things

A biologist's concept may be represented:

living things

plants other living things

flowering plants ferns pine trees
e.g. vegetables
weeds.

Some pupils did view the weeds, vegetables and seeds as subsets of class 'plant' but only four considered all of them as subsets.

Most of the pupils interviewed, despite up to three years of formal secondary school tuition had not developed a scientifically acceptable concept of a plant.

Reference

Osborne, R.J. and Gilbert, J.K.

Investigating Student Understanding of Basic Concepts using an Interview-about-Instances Approach.

Research in Science Education, vol. 9, 1979, p. 85-93.

Acknowledgements

I wish to thank Peter Freyberg, Roger Osborne and Ross Tasker for their valuable discussions and comments relating to the interviews and the preparation of this paper.

	Standard 4	Form 1	Form 3	Form 5	Total
Numbers	8	7	7	7	29
Pupil Code	(019-026)	(117-123)	(318-324)	(517-523)	

Pupils of above average ability 521, 522.

Second year Form 5 pupils 517, 518, 519, 520.

Figure 1. The interview sample.

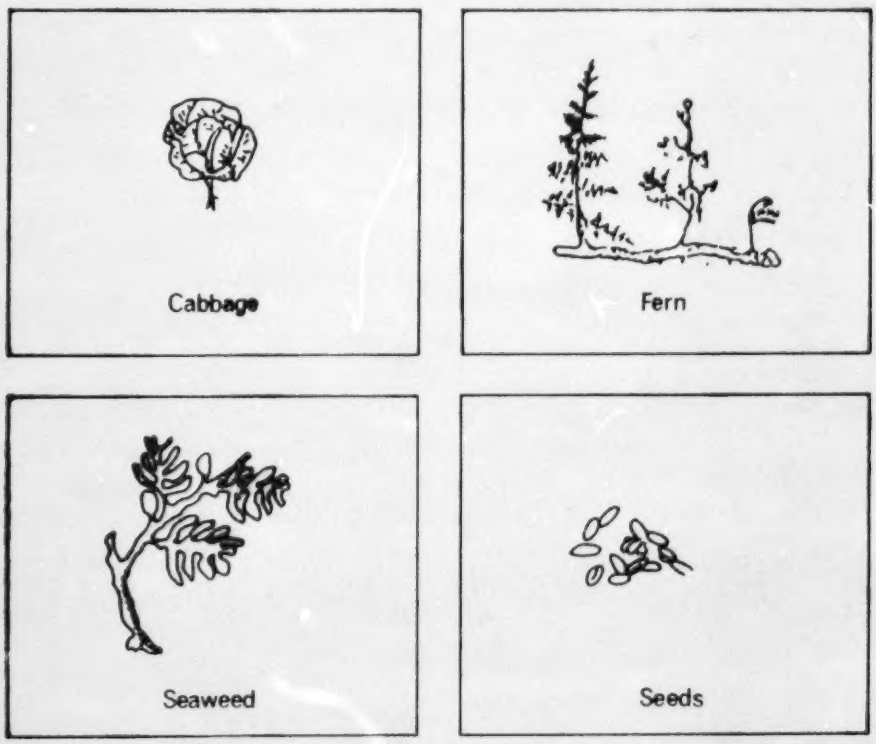

Figure 2. A sample of the cards used in the interviews.

1. The Use of Scientifically acceptance Criterial Attributes

   a. It grows in the ground
   b. Leaves
   c. Flowers
   d. Stem
   e. Colour
   f. Roots
   g. Requirements
   h. Immobility

2. The Use of Scientifically Unacceptable Criterial Attributes

   a. Size
   b. Hardness
   c. Plants are those which are cultivated
   d. Soil as a food source
   e. Idiosyncratic uses of a characteristic

3. The Use of Criterial Attributes of Living Things as the Criterial Attributes of Plants.

4. The Atypical Plants.

   a. Seaweed
   b. Mushrooms
   c. Vegetables
   d. Seeds

Table 1. The framework of the analysis.

Appendix

Supplementary Interview Transcripts

The following are quotations from the interview transcripts that were not included in the main section.

The headings are identical to those used in the main section, where an explanation of the headings may also be found.

The use of Scientifically Acceptable Criterial Attributes

a. Grows in the Ground

"It grows in the ground." grass, 023, 026, 117, 119, 122, 318, 321, 322, 518, 522
poppy, 019, 117, 122, 318, 322, 324, 517, 521,
tree, 022, 117, 122, 318, 321, 324, 517
mushroom, 026, 117, 122, 321, 521
fern, 117, 119, 120, 122, 321, 322, 324, 521, 522
dandelion, 022, 119, 122, 321, 324
gorse, 019, 122, 321, 324
thistle, 022, 119, 121, 324, 517, 518
pinetree, 117, 121, 122, 321, 522
cabbage, 119, 321
seaweed, 517

b. Leaves

"Yes, ... its got leaves .." grass, 022, 024, 122, 517, 519
poppy, 022, 023, 118, 122, 520, 522
dandelion, 021, 022, 023, 024, 026, 118, 119, 122, 318, 319, 324, 502
fern, 022, 118, 119, 121, 319, 323, 324, 522
thistle, 022, 021, 026, 118, 119, 122, 318, 324, 521, 522,
gorse, 022, 118, 318
tree, 022, 118, 119, 122, 318, 319, 323, 324
pinetree, 118, 121, 319, 323, 324
seaweed, 024, 026, 121, 324, 517, 521

c. Flowers

"Yes, ... its got flowers." poppy, 022, 021, 023, 024, 025, 026, 118, 120, 121, 319, 321, 322, 323, 324, 517, 519, 520
thistle, 022, 021, 024, 026, 118, 323, 324, 520, 522
dandelion, 022, 024, 118, 120, 121, 321, 324
gorse, 022, 024, 117, 122, 324

d. Stem

"Yes, ... the stem." grass, 024
poppy, 024, 119, 318, 520
dandelion, 026, 119, 318, 324, 523
thistle, 119, 318, 324, 520
fern, 119, 319, 521, 522

"Yes, ... the trunk is like the stem of a flower."
tree, 024, 119, 121
pinetree, 319

e. Colour

"Yes, ... it's green." poppy, 021, 321
grass, 022, 318, 321, 517, 523
fern, 022, 320, 321, 324, 517
dandelion, 022, 320, 523
gorse, 022, 318, 324
tree, 022, 321, 517
thistle, 321, 517
seaweed, 022, 321

"No, ... its got no chlorophyll."
mushroom, 520

f. Roots

"Yes ... it has roots like other plants."
grass, 322, 519
poppy, 318
dandelion, 318, 523
tree, 120, 318, 324, 523
fern, 520, 521

g. Requirements

"They (plants) need sunlight, they need water ..."
bracken, 023, 318
pinetree, 318
mushroom, 320

"Yes, ... and it needs air, water, sunlight."
tree, 122

"Yes, ... and they need water."
fern, 122
gorse, 318, 321

"Yes, ... it needs sun and it needs water and minerals."
grass, poppy, 319

"Yes, ... the sun and that helps it grow."
tree, 523

"Yes, ... needs water and soil to help it grow."
fern, 523

h. Immobility

"Yes, ... it doesn't talk and walk .."
fern, 123; poppy, 320

"Yes, doesn't move to get its food .. stays in one place."
mushroom, 519

"Yes, .. you put it in the position and there it stays."
tree, 320, 519
mushroom, 320
pinetree, 323; poppy, 521

"Yes, .. and it doesn't run around."
seaweed, 123, 320, 519

The Use of Scientifically Unacceptable Criterial Attributes

a. Size

"A plant would be ... its height would be about knee height, and it would be a greeny colour."
tree, 321

"Its a form of plant. Trees are a different kind because they grow alot bigger." tree, 521

b. Hardness

"No, because a plant is usually small and a tree is made of wood and its much harder." tree, 518, 521

c. Plants are those that are Cultivated

"Yes, I think we grow it." poppy, 020

"Yes, ... it doesn't grow wild, you need to grow it."
poppy, 320

"Yes, ... you plant it yourself."
carrot, 320, 021

"Yes, ... we get the seeds and we plant the dandelion in our garden ."
dandelion, 020
fern, 323
tree, 320
cabbage, 020

"No, because the grass just comes out of the ground."
grass, 019, 020, 323

"No, it grows out of grass or other plants."
thistle, gorse, 020

"I'm not sure ... because we don't grow it. We don't go under the sea and grow it." seaweed, 020

e. Idiosyncratic Uses of a Characteristic

"Yes, ... from this book I read, its got the plant that saved Scotland." thistle, 023

"Yes, (What tell you that?) Weed. (The actual part of the word?) Yes." seaweed, 188

"No, it doesn't look like a plant."
mushroom, 322, 323, 517

"Suppose so. Most trees grow from clippings and some plants grow from clippings." tree, 025

"No, because its sort of grows long and then it comes out like that. It doesn't have the tree coming out of the ground - the leaves coming straight out of the ground."
tree, 026; grass, 121

The Use of the Criterial Attributes of Living Things as Criterial Attributes of Plants

"Yes, it grows."
grass, 120, 123, 319, 519, 521
fern, 022, 026, 121, 518
poppy, 023, 123, 323, 523
dandelion, 023, 117, 123
carrot, 023

tree, 023, 117, 120, 123, 319, 323
gorse, 117, 120, 123
seaweed, 026, 120, 122, 123, 319, 322, 323, 519, 522, 523
thistle, 120, 321, 323, 523
mushroom, 120, 123
pinetree, 324

"Yes, ... (its) able to reproduce itself." grass, poppy, 521

"Yes, its living." gorse, 121

The Atypical Plant

c. The vegetables Examples of the restriction of the concept 'plant':

"Vegetable ... you can go and buy vegetables from the store and you can eat them for tea, you can't have a plant." mushroom, 019, 517, 523; carrot, 319; cabbage, 319

"No, (its a) vegetable." cabbage, 019, 117, 321, 521, 523

"No, (its a) vegetable because that grows out of a plant." carrot, 020

"No,... (What tells you that?) This part here - the carrot." carrot, 024

"No, shape of it, its vegetable, you don't see plants that really grow like that." carrot, 118

"No, ... the roots are different." carrot, 520

"No, ... I'd say it was a vegetable ... by its leaves." cabbage, 518

"No, ... It hasn't got a stem or leaves but its got leaves but its food." cabbage, 520

d. Seeds

"No, at that stage they haven't got leaves and they haven't got flowers, they're just a round oval shape." (022)

"No, but the plants do grow from seed." (025, 023, 120, 319, 320, 523)

"No, because they don't have anything (leaves etc)." (024)

"No, ... when they grow they'll be plants ... (they've) no leaves." (121, 122)